#13/A. Brief
6-27-01
Harrison

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Goldberg (TI-25588)

Serial No. 09/085,298 Group Art Unit: 2823

Filed: May 27, 1998 Examiner: K. Eaton

For: Method for Thermal Nitridation and/or Oxidation of Semiconductor Surface and Related Processing Equipment

APPELLANT'S BRIEF

Commissioner for Patents
Washington, DC 20231

Dear Sir:

Appellant respectfully presents their brief in support of their appeal of the final rejection of claims in this case. The Notice of Appeal was filed on February 14, 2001, as evidenced by the return postcard received by the undersigned.

Real Party in Interest

The real party in interest in this application is Texas Instruments Incorporated.

Related Appeals and Interferences

The undersigned is aware of no appeals or interferences which will directly affect or have a bearing on, or be directly affected by, the Board's decision in this appeal.

Status of the Claims

Claims 1 through 5, 7 through 10, and 13 were finally rejected in the Office Action of October 11, 2000, and are the subject of the present appeal.

Status of Amendments

Amendment to claim 8 was presented after the final rejection. No indication was made in the Advisory Action of March 9, 2001 regarding whether the amendment was entered. Because the proposed amendment to claim 8 only concerned punctuation, Appellant presumes that the amendment was entered.

The claims on appeal are presented in the Appendix to Appellant's Brief. This Appendix presents claim 8 in its amended form.

Summary of the Invention

The present invention is directed to a method of forming thin dielectric films of a high dielectric constant in a semiconductor integrated circuit. According to the invention, nitrogen and oxygen gases are supplied to the interior of a chamber that contains the silicon structure upon which the dielectric film is to be deposited. Nitridation and oxidation of the silicon structure takes place upon raising the ambient temperature of the chamber and striking of a plasma in the chamber, in the presence of these gases.[1]

This invention provides a dielectric film of high structural integrity, suitable for use as a capacitor dielectric or a gate dielectric for high-performance transistors.[2] The inclusion of the nitrogen gases provides a thin film that has a higher dielectric constant than a conventional thermal silicon dioxide film,[3] while still obtaining many of the important electrical characteristics of an oxide film.[4]

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[1] Specification of S.N. 09/085,298, at page 7, lines 3 through 17; page 9, line 5 through page 10, lines 6, relative to Figures 3a and 3b.
[2] Specification, *supra*, page 6, line 29 through page 7, line 2.
[3] Specification, *supra*, page 2, lines 1 through 9.
[4] Specification, *supra*, page 3, lines 5 through 9; page 4, lines 7 through 10; page 7, lines 13 through 17.

Issues

Are claims 1 through 5, 7 through 10, and 13 patentable over the Nozaki et al. reference[5], individually or in combination with the Tseng reference[6]?

Grouping of the claims

The claims stand or fall together.

Argument

The rejection

Claims 1 through 4, 7, 8, and 13 were finally rejected under §103 as unpatentable over the Nozaki et al. reference. Claims 5, 7, 9, and 10 were finally rejected under §103 as unpatentable over the Nozaki et al. reference in view of the Tseng reference.

In making the rejection, the Examiner admitted that the Nozaki et al. reference fails to disclose that the nitrogen containing gas also includes oxygen, and fails to disclose that the plasma also causes thermal oxidation of a portion of the underlying silicon containing structure.[7] To make up for this lack of teaching, the Examiner asserted that, because the thermally nitrided portion of the silicon containing structure also contained oxygen, oxygen must have been incorporated within the nitrogen-containing gas of the Nozaki et al. reference, and asserted that it would have been further obvious that the silicon that was thermally nitrided would also have been thermally oxidized.[8] In clarifying this point, the Examiner states that, according to his interpretation, "oxygen is naturally present within the nitrogen containing gas, as is evidenced from the data given in Table 1" of the Nozaki et al. reference.[9]

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[5] U.S. Patent No. 4,298,629, to Nozaki et al.
[6] U.S. Patent No. 5,643,819, to Tseng.
[7] Office Action of October 11, 2000, p. 2.
[8] *Id.*
[9] Advisory Action of March 9, 2001, ¶1 (emphasis in original).

Appellant's argument

It is axiomatic, in the patent law, that a *prima facie* obviousness determination of patent claims requires teachings from the prior art itself to appear to have suggested the claimed subject matter to a person of ordinary skill in the art.[10] If the Examiner fails to establish a *prima facie* case, the rejection is improper and should be overturned on appeal.[11]

Appellant respectfully submits that the final rejection fails to meet this standard. Instead, the teachings of the applied prior art, properly interpreted, fall short of the requirements of each of the claims, and there is no suggestion from the prior art to modify those teachings in such a manner as to reach the claims on appeal in this case.

Claim 1 and its dependent claims

Independent claim 1 requires the steps of providing a gas comprising of a mixture of nitrogen and oxygen to a silicon-containing structure, heating the structure to an elevated temperature greater than 700C, and striking a plasma above the structure to cause thermal nitridation and thermal oxidation of a portion of that structure. Appellant submits that the Nozaki et al. reference fails to disclose the providing of the gas comprised of a mixture of nitrogen and oxygen, and therefore necessarily fails to disclose the striking of a plasma to cause thermal nitridation and thermal oxidation of the underlying structure.

As noted above, the rejection of claim 1 and its dependent claims 2 through 5 is based on the Examiner's deduction that oxygen is "naturally" present in the nitrogen-containing gas used in the method of the Nozaki et al. reference. Appellant disputes this interpretation of the reference. Appellant understands that the Nozaki et al. reference does disclose that the nitrided film resulting from its disclosed method includes oxygen.[12] However, the reference nowhere discloses that this oxygen is present in the reacting gas or gases. Rather, the reference states that a high concentration of oxygen results "from ammonia and a nitridation reaction tube made of

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[10] *In re Rijckaert*, 9 F.3d 1531, 1532, 28 USPQ2d 1955, 1956 (Fed. Cir. 1993).
[11] *Id.*
[12] Nozaki et al., *supra*, column 6, Table 1.

quartz".[13] Accordingly, Appellant respectfully submits that, because the reference discloses the quartz reaction tube as the source of oxygen in its film, the Examiner's assertion that "oxygen must have been incorporated within the nitrogen containing gas"[14] is unfounded speculation. Rather, the skilled reader would understand, from the Nozaki et al. reference, that any oxygen foreign matter in the nitrided film is from the quartz reaction tube, and not from any oxygen that is naturally present in the reacting gas.

In addition, Appellant submits that the reference discloses only the use of reactive gases that do not include oxygen. The Nozaki et al. reference lists its available gas sources as: nitrogen gas, hydrogen gas, ammonia gas, hydrogen chloride gas, and chlorine gas.[15] Hydrazine (N_2H_4) is also disclosed as a nitrogen-containing gas, and argon (Ar) is given as an example of an essentially inert gas that may be mixed with the nitrogen-containing gas.[16] Oxygen is not listed as one of the available gases, and oxygen is not a constituent of any of these gases. There is no disclosure in the reference that these gases are in any way mixed with oxygen, either intentionally or naturally. Indeed, the reference teaches that, for the example of ammonia gas, the purity of the gas is 99.99% or higher,[17] leaving precious little room for any significant amount of oxygen that may naturally be present or mixed into this gas. Accordingly, Appellant submits that one skilled in the art, fairly reading the Nozaki et al. reference, would not be taught by the reference to provide a gas comprising a mixture of nitrogen and oxygen, nor would that artisan be taught that oxygen is naturally present within any of the nitrogen-containing gases.

Appellant also disputes the assertion of the Examiner that it would have been obvious, from the Nozaki et al. reference, that the thermally nitrided portion of its silicon-containing structure would also have been thermally oxidized[18]. There is no teaching in the Nozaki et al. reference of the thermal oxidation of the underlying structure. Instead, the reference clearly

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[13] Nozaki et al., *supra,* column 2, lines 35 through 38.
[14] Advisory Action, *supra,* p. 2.
[15] Nozaki et al., *supra,* column 4, lines 33 through 36.
[16] Nozaki et al., *supra,* column 3, lines 22 through 29.
[17] Nozaki et al., *supra,* column 7, lines 58 and 59.
[18] *See* Office Action of October 11, *supra,* p. 3, lines 1 and 2.

states that the oxygen "is adsorbed on the surface of the silicon nitride films as foreign matter"[19]. The reference fails to disclose that the oxygen on the film is even in reacted form, much less as an oxide due to the oxidization of the underlying silicon-containing structure. Appellant therefore submits that this assertion by the Examiner is in error and that, to the extent that the final rejection of claim 1 and its dependent claims is based on this assertion, the final rejection is therefore also in error.

For these reasons, Appellant submits that the Nozaki et al. reference fails to teach the providing of a gas comprising a mixture of nitrogen and oxygen to a silicon-containing structure, and therefore necessarily fails to disclose the step of striking a plasma to cause thermal nitridation and thermal oxidation of a portion of said silicon-containing structure, both steps required by the claims. The Tseng reference was not asserted by the Examiner as adding any teachings in this regard, and in fact the Tseng reference does not provide any such teachings. Accordingly, the combined teachings of the Nozaki et al. and Tseng references fall short of the requirements of claim 1.

Appellant further submits that there is no suggestion from the prior art to modify these teachings in such a manner as to reach claim 1. The Nozaki et al. reference is specifically directed to the reduction of oxygen, as a contaminant or "foreign matter", in its formation of a nitride film[20]. This clear intent of the Nozaki et al. teachings negates any suggestion from the prior art to modify its teachings to include oxygen in its reacting gases. Instead, the skilled reader of the Nozaki et al. reference would be encouraged to reduce oxygen in a nitridation reaction, and discouraged from intentionally adding oxygen. It is well-settled that an invention that might be viewed as an obvious modification of the prior art cannot be deemed obvious when one or more prior art references ``teach away'' from the invention.[21] Accordingly, Appellant respectfully submits that there can be no suggestion from the prior art to modify the

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[19] Nozaki et al., *supra*, column 6, lines 19 through 21.

[20] Nozaki et al., *supra*, column 2, lines 64 through 68; column 6, lines 19 through 31; column 7, lines 58 through 62.

[21] *Gillette Co. v. S.C. Johnson & Sons, Inc.*, 919 F.2d 720, 724, 16 USPQ2d 1923, 1927 (Fed. Cir. 1990).

teachings of the applied references in such a manner as to reach the requirements of claim 1 and its dependent claims.

Appellant therefore respectfully submits that the final rejection of claims 1 through 5 under §103 is in error, and should be reversed.

Claim 7 and its dependent claims

Independent claim 7 is directed to a method of forming an electrical device which has a dielectric formed between a bottom structure and a top structure. The claimed method requires the steps of providing a gas comprising of a mixture of nitrogen and oxygen over a bottom structure, heating the structure to an elevated temperature greater than 900C, and creating a plasma over the bottom structure to cause thermal nitridation and thermal oxidation of the bottom structure so as to form a dielectric thereover. The method is completed by forming a top structure over the dielectric.

For the same reasons as discussed above relative to claim 1, Appellant submits that the Nozaki et al. reference fails to disclose the providing of a gas comprised of a mixture of nitrogen and oxygen, and therefore necessarily fails to disclose the creating of a plasma to cause thermal nitridation and thermal oxidation of the bottom structure so as to form a dielectric on that structure.

To summarize these arguments, Appellant submits that the premise upon which the rejection of claim 7 and its dependent claims 8 through 10 is based, is incorrect. The Examiner asserts that oxygen is "naturally" present in the nitrogen-containing gas used in the method of the Nozaki et al. reference, because of the appearance of oxygen in the resulting nitrided film. Appellant disputes this assumption, because the reference itself clearly states that the oxygen results "from ammonia and a nitridation reaction tube made of quartz",[22] and nowhere discloses that oxygen is present, either intentionally or naturally, in its reactive gases. Also as discussed above relative to claim 1, the reference fails to disclose any oxidation, instead teaching that its oxygen "foreign matter" is adsorbed at the surface of the nitrided film.

Appellant therefore submits that the final rejection of independent claim 7 is either based on an erroneous interpretation of the reference, or based on improper speculation about the teachings of the reference using Appellant's disclosure in hindsight.

Appellant submits that the Nozaki et al. reference therefore fails to teach the providing of a gas comprising a mixture of nitrogen and oxygen to a bottom structure, and therefore necessarily fails to disclose the step of creating a plasma to cause thermal nitridation and thermal oxidation of a portion of that bottom structure, as required by claim 7. The Tseng reference was not asserted by the Examiner as adding any teachings in this regard, and in fact the Tseng reference does not provide any such teachings. The combined teachings of the Nozaki et al. and Tseng references thus fall short of the requirements of claim 7.

Also as discussed above relative to claim 1, Appellant further submits that there is no suggestion from the prior art to modify the teachings of the applied references in such a manner as to reach claim 7. Because the Nozaki et al. reference, fairly read, discourages the incorporation of oxygen in its film, referring to oxygen as a contaminant or "foreign matter", in its nitride film[23], the skilled reader of the Nozaki et al. reference would be discouraged to intentionally adding oxygen to the gases provided to the structure. Because of this teaching away by the Nozaki et al. reference, Appellant respectfully submits that there can be no obvious suggestion from the prior art to modify the teachings of these references in such a manner as to reach the requirements of claim 7 and its dependent claims.

Appellant therefore respectfully submits that the final rejection of claims 7 through 10 under §103 is in error, and should also be reversed.

Claim 13

Independent claim 13 is directed to a method of forming a gate dielectric layer on a semiconductor substrate. The claimed method requires the steps of providing a gas comprised

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[22] Nozaki et al., *supra*, column 2, lines 35 through 38.
[23] Nozaki et al., *supra*, column 2, lines 64 through 68; column 6, lines 19 through 31; column 7, lines 58 through 62.

of a mixture of nitrogen and oxygen, heating a semiconductor substrate to an elevated temperature greater than 900C, subjecting the semiconductor substrate to a plasma, where the combination of the gas, elevated temperature, and plasma results in thermal nitridation and thermal oxidation of a portion of the substrate, and then forming a gate electrode over the nitrided and oxidized portion.

For the same reasons as discussed above relative to claims 1 and 7, Appellant submits that the Nozaki et al. reference fails to disclose the providing of a gas comprised of a mixture of nitrogen and oxygen, and therefore necessarily fails to disclose the subjecting of a substrate to a plasma that, in combination with the provided gas and elevated temperature, results in thermal nitridation and thermal oxidation of the substrate.

In summary, Appellant submits that the basis of the rejection of claim 13 is in error. The stated basis of the rejection is that oxygen must "naturally" be present in the nitrogen-containing gas used in the method of the Nozaki et al. reference, because oxygen is present in the resulting nitrided film. This is in contradiction to the clear statement in the reference that oxygen in its film results "from ammonia and a nitridation reaction tube made of quartz".[24] Nowhere does the reference disclose that oxygen is present in any of its reagent gases, either intentionally or naturally, or even that any oxidation takes place. The skilled reader of the Nozaki et al. reference would therefore not be taught to provide a gas comprising a mixture of nitrogen and oxygen, or that oxygen is naturally present within any of the nitrogen-containing gases, but would instead learn that any oxygen in the film is a contaminant ("foreign matter") coming from the quartz reaction tube. Appellant therefore submits that the final rejection of independent claim 13 is in error.

Appellant therefore submits that the Nozaki et al. reference lacks teachings regarding the providing of a gas comprised of a mixture of nitrogen and oxygen, and therefore necessarily lacks teachings regarding the subjecting of a substrate to a plasma that, in combination with the gas and an elevated temperature, effects thermal nitridation and thermal oxidation of a portion of the substrate, as required by claim 13. Because the Tseng reference provides no teachings in

this regard, the combined teachings of the applied references fall short of the requirements of claim 13.

Also as discussed above relative to claims 1 and 7, Appellant submits that there is no suggestion from the prior art to modify the teachings of the applied references in such a manner as to reach claim 13. Instead the Nozaki et al. reference is directed to reducing the "foreign matter" of oxygen in its nitride film, and therefore teaches away from intentionally adding oxygen to its reactive gases. Appellant therefore respectfully submits that there is no obvious suggestion from the prior art to modify the teachings of these references in such a manner as to reach the requirements of claim 13.

Appellant therefore respectfully submits that the final rejection of claim 13 under §103 is in error, and should be reversed.

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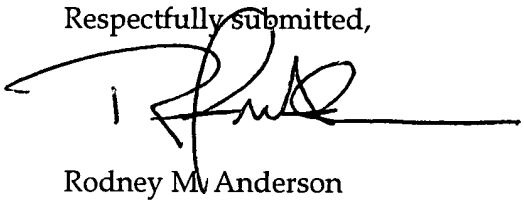
[24] Nozaki et al., *supra,* column 2, lines 35 through 38.

Conclusion

For these reasons, Appellants submit that the final rejection of claims 1 through 5, 7 through 10, and 13 under §103, is in error. Reversal of the final rejection of the claims in this case is therefore respectfully requested.

Respectfully submitted,



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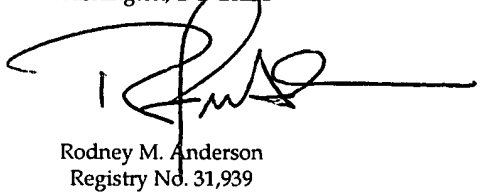

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In re the Application of

Goldberg (TI-25588)

Serial No. 09/085,298 Group Art Unit: 2823

Filed: May 27, 1998 Examiner: K. Eaton

For: Method for Thermal Nitridation and/or Oxidation of Semiconductor Surface and Related Processing Equipment

APPENDIX TO APPELLANT'S BRIEF

Commissioner for Patents

Washington, DC 20231

Dear Sir:

Appellant respectfully presents the claims on appeal in this case:

1. A method of forming a dielectric layer on a silicon-containing structure, said method comprising the steps of:

providing, to a silicon-containing structure, a gas comprising a mixture of nitrogen and oxygen;

heating said silicon-containing structure to an elevated temperature greater than 700C; and

striking a plasma above said silicon-containing structure to cause thermal nitridation and thermal oxidation of a portion of said silicon-containing structure.

2. The method of claim 1, wherein said elevated temperature is greater than 900C.

3. The method of claim 1, wherein said elevated temperature is greater than 1000C.

4. The method of claim 1, wherein said silicon-containing structure is a silicon substrate and a gate dielectric is formed from the thermal nitridation and thermal oxidation of said silicon-containing structure.

5. The method of claim 1, wherein said silicon-containing structure is a bottom electrode of a storage capacitor of a memory device and a capacitor dielectric is formed from the thermal nitridation and thermal oxidation of said silicon-containing structure.

7. A method of forming an electrical device which has a dielectric formed between a bottom structure and a top structure, said method comprising the steps of:

providing a gas comprising a mixture of nitrogen and oxygen over a bottom structure;

heating said bottom structure at an ambient temperature at least 900C;

creating a plasma over said bottom structure to cause thermal nitridation and thermal oxidation of said bottom structure so as to form a dielectric over said bottom structure; and

forming a top structure over said dielectric.

8. The method of claim 7, wherein said bottom structure is a silicon substrate and said top structure is a gate structure.

9. The method of claim 7, wherein said bottom structure is a bottom electrode of a storage capacitor of a memory device.

10. The method of claim 7, wherein said ambient temperature is around 1000C.

13. A method of forming a gate dielectric layer on a semiconductor substrate, said method comprising the steps of:

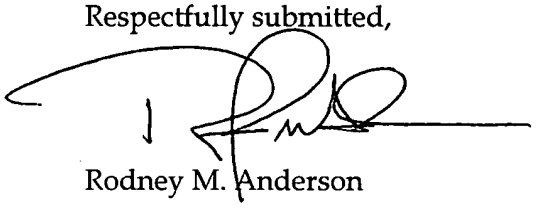
providing a gas comprised of a mixture of nitrogen and oxygen;

heating said semiconductor substrate to an elevated temperature greater than 900C;

subjecting said semiconductor substrate to a plasma, wherein the combination of said gas, said elevated temperature, and said plasma result in thermal nitridation and thermal oxidation of a portion of said semiconductor substrate; and

forming a gate electrode over said nitrided and oxidized portion of said semiconductor substrate.

Respectfully submitted,



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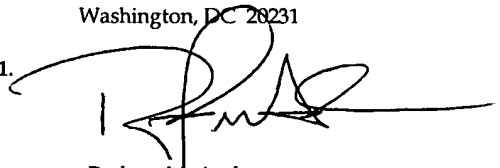

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